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TECHNICAL REPORT 2360

# INVESTIGATION OF COMPOSITION B AND CYCLOTOL FOR USE IN 60 MM M49A2 HE SHELL

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SEPTEMBER 1956



SAMUEL FELTMAN AMMUNITION LABORATORIES
PICATINNY ARSENAL
DOVER, N. J.

ORDNANCE PROJECT TA1-3501
DEPT. OF THE ARMY PROJECT 5A04-03-053

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INVESTIGATION OF COMPOSITION B AND CYCLOTOL FOR USE
IN 60MM M49A2 HE SHELL                                    (C)

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D.;
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DESCRIPTORS:  *EXPLOSIVES, *FRAGMENTATION, HIGH EXPLOSIVE
AMMUNITION, MATERIALS, MORTAR AMMUNITION, PROJECTILES,
TESTS                                                     (M)
IDENTIFIERS:  60-MM ORDNANCE ITEMS, M-49 CARTRIDGES(60-
MM)                                                       (M)

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Investigation of Composition B and Cyclotol for use in 60MM M49A2 HE Shell. (U)

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# INVESTIGATION OF COMPOSITION B AND CYCLOTOL FOR USE IN 60 MM M49A2 HE SHELL (C)

by

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September 1956

Picatinny Arsenal
Dover, N. J.



Technical Report 2360

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Approved:

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Ammunition Laboratories

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## OBJECT

To investigate the use of Composition B and cyclotol as the bursting charge in 60 mm M49A2 HE shell.

## SUMMARY

In an attempt to improve the fragmentation efficiency of the 60 mm M49A2 HE shell (which is press-loaded with flake TNT), Picatinny Arsenal began an investigation of the use of cast Composition B and cyclotol as the bursting charge in this shell.

Panel recovery tests were conducted with nine M49A2 shell, three loaded with pressed TNT, three with cast Composition B, and three with cast cyclotol. From the results of these tests lethal areas at ground burst were calculated:

| Angle of Elevation of Mortar | Lethal Area (sq ft) of M49A2 Shell Loaded with TNT | Composition B | Cyclotol |
|---|---|---|---|
| 45° | 186 | 241 | 256 |
| 65° | 352 | 456 | 488 |

The investigation was discontinued when production of the M49A2 shell was terminated.

## CONCLUSION

Both Composition B and 75/25 cyclotol produce more effective fragmentation of the 60 mm M49A2 HE shell than pressed TNT. Cyclotol is slightly more effective than Composition B.

## RECOMMENDATION

It is recommended that the use of Composition B and 75/25 cyclotol in other small fragmentation-type ammunition be investigated.

## INTRODUCTION

1. Press-loaded flake TNT was standardized as the bursting charge for 60 mm M49A2 HE shell early in World War II. Because it was then believed that fragmentation in the smaller grain sizes was undesirable, cast TNT was considered too brisant for this shell. Recently, however, it has been recognized that more and smaller fragments of higher velocity provide greater lethality.

2. In 1954 Picatinny Arsenal was requested (Ref 1) to improve the loading of 60 mm M49A2 HE shell as a part of a comprehensive program to replace TNT with Composition B as the standard loading for all HE shell which would thereby be improved. An investigation was therefore started to determine the suitability of cast Composition B as the bursting charge in the M49A2 shell. Because cyclotol had been shown to be superior to Composition B in fragmentation ammunition (Ref 2), the use of cyclotol as the bursting charge for this shell was also investigated.

3. It was planned to conduct panel recovery, pit fragmentation, safety, and functioning tests of M49A2 shell loaded with pressed flake TNT, cast Composition B, and cast cyclotol. Because production of the M49A2 shell had been terminated, however, this investigation was discontinued (Ref 3) after only the panel recovery tests had been completed. This report covers the results of these tests.

## RESULTS

4. Nine 60 mm M49A2 HE shell, three loaded with pressed flake TNT, three with cast Composition B, and three with cast cyclotol, were subjected to panel recovery tests. The results of these tests are given in Table 1 and may be summarized as follows:

| | Bursting Charge | | |
|---|---|---|---|
| | TNT | Comp B | Cyclotol |
| Avg no. of hits per shell | 86 | 156 | 164 |
| Avg no. of perforating hits per shell | 35 | 59 | 68 |
| Avg fragment velocity, ft/sec | 3830 | 4700 | 5080 |
| Avg wt of velocity fragments, grains | 11.8 | 7.1 | 6.5 |
| Avg no. of fragments larger than 1 grain | 67 | 95 | 103 |
| Avg wt of fragments larger than 1 grain | 12.8 | 8.7 | 6.3 |

5. Lethal areas against prone men at ground burst for mortar elevations of 45° and 65°, calculated (Ref 4) from the results of the panel recovery tests, were as follows:

| | Bursting Charge | | |
|---|---|---|---|
| | TNT | Comp B | Cyclotol |
| Lethal Area at 45°, sq ft | 186 | 241 | 256 |
| Lethal Area at 65°, sq ft | 352 | 456 | 488 |

## DISCUSSION OF RESULTS

6. Both the panel penetration and fragment velocity test results agree with theoretical considerations. The results of the panel penetration tests show that both Composition B- and cyclotol-loaded shell produced nearly twice as many hits as shell press-loaded with flake TNT. Cyclotol-loaded shell produced 5% more hits than Composition B-loaded shell. Analysis of the fragment velocity results reveals that Composition B and cyclotol, respectively, produced 23 and 33% greater fragment velocity than TNT and showed a corresponding decrease in the size of the velocity fragments. Although velocities were recorded for only one TNT-and one Composition B-loaded shell, the fact that an increase in detonation rate of the bursting charge causes greater fragment velocities and increases the number of fragments further substantiates the results obtained.

7. Analysis of the fragment weight distribution data of Table 1 shows that shell loaded with either Composition B or cyclotol produced a larger number of fragments in the 1 to 25-grain size range than shell loaded with pressed TNT. Cyclotol produced a slightly larger number of fragments in this size range. No significant difference is apparent in the number of fragments larger than 25 grains produced by the different explosives. These results indicate that cyclotol is slightly more effective as the bursting charge for the subject shell than Composition B, which, in turn, is considerably more effective than pressed TNT.

8. The values for the lethal areas presented in paragraph 5 represent the cumulative effects of spatial distribution of fragments, fragment velocity, panel penetration, and the number and weight of recovered fragments. If we assume a terrain limitation at a radius of 14 feet at ground burst, the following average kill probabilities are obtained by dividing the appropriate lethal area by the area contained within the terrain limitation.

| | Kill Probability | | |
|---|---|---|---|
| Mortar Elevation | TNT | Composition B | Cyclotol |
| 45° | .30 | .39 | .42 |
| 65° | .57 | .74 | .79 |

These values indicate the probability that a fatal wound will be inflicted on a prone human target within the terrain limitation. It is also seen that cyclotol is slightly more lethal than Composition B, which is considerably (about 30%) more lethal than TNT.

9. Because production of this shell has ceased and no further production is planned, further investigation of various explosives for use in this shell is not warranted. These results show, however, the improved fragmentation that can be gained by using cyclotol and Composition B in HE shell. Further studies of these explosives in other small fragmentation-type ammunition currently loaded with TNT should therefore be expedited.

## EXPERIMENTAL PROCEDURE

### Shell Assembly

10. Nine 60 mm M49A2 HE shell, Type A, (Fig 1) were loaded with TNT, Composition B, and 75/25 cyclotol described below:

a. Three shell were loaded with about 0.34 lb Grade I flake TNT (Spec JAN-T-248, 29 September 1955) pressed in two approximately equal increments. The first increment was pressed in two approximately equal increments. The first increment was pressed at 2000 psi with a 1.15-inch-diameter flat punch. The second increment was pressed to form the fuze cavity in accordance with Figure 2 at a pressure not exceeding 5000 psi with a 1.15-inch-diameter forming punch

b. Three shell were loaded with cast Grade A Composition B (Spec PA-PD-24, Rev 1, 13 August 1953) in one pour at 86°C ±1°. A thread-protecting funnel was used. The shell were filled to within one inch of the funnel top. The fuze cavity was drilled to the dimensions shown in Figure 2

c. Three shell were loaded with cast 75/25 cyclotol (Spec PA-PD-222, Rev 1, 31 July 1953) according to the procedure outlined in paragraph 10 (b) except that the pouring temperature was $90^{o}C \pm 1^{o}$.

11. Nine M52A2B1 fuzes (Fig 3) were modified for static firing. The head assembly, booster cup with booster pellet, and booster lead cup with booster lead charge were removed. The body assembly was then disassembled and the axial hole diameter of the fuze body was increased by drilling to 0.290" + 0.010" to accomodate a Type II special blasting cap. The booster cup with booster pellet was then reassembled to the fuze body. A modified fuze, sealed with tape to exclude moisture, was assembled to each loaded shell.

Panel Recovery Test

12. The assembled shell were detonated in a horizontal position by a Type II special blasting cap which was inserted into the modified fuze (Fig 4) just before firing. Fragments were recovered from 10 celotex boxes arranged in a semicircle 14.8 feet from the shell firing position. A semicircular fence of 1-inch pine panels 9 feet in height and 30 feet from the shell firing position was used to obtain spatial distribution of fragments and panel perforation and penetration data. The fragment velocities were obtained by the use of two Fastax motion picture cameras operating at approximately 12,000 frames per second. Figure 5 shows a plan view of the panel recovery test set-up. Complete details of these tests are given in Reference 5.

REFERENCES

1. Letter from Office, Chief of Ordnance, to Picatinny Arsenal, 25 January 1954, ORDTA 00/4UO-3247, ORDBB 471.86/73-3, Subject: Explosive Loading of Shell, HE, 60 mm, M49A2

2. L. Jablansky, Evaluation of 70/30 Cyclotol and 75/25 Cyclotol for Use in HE and HEAT Projectiles, Picatinny Arsenal Technical Report 1944, 25 August 1953

3. Letter from Office, Chief of Ordnance, to Picatinny Arsenal, 8 June 1955, ORDTA 00/75U0 21895, ORDBB 471.86/7-23, Subject: Explosive Loading of Shell, HE, 60 mm, M49A2

4. Letter from Aberdeen Proving Ground to Picatinny Arsenal, 26 September 1955, ORDBG-BRL-W, ORDBB 471.86/7-51, Subject: Lethal Areas of Shell, HE, 60 mm M49A2 (U)

5. Yuma Test Station Firing Record No. 2024

TABLE 1

Panel Penetration, Fragment Velocity, and Fragment Weight Distribution Results of 60 mm M49A2 HE Shell Loaded with Pressed Flake TNT, Composition B, and 75/25 Cyclotol

| | | Panel Penetration* | | | | Fragment Velocity** | |
|---|---|---|---|---|---|---|---|
| Round Number | Explosive Filler | Perforations | Penetrations | Total Hits | % Perf. of Total Hits | Avg Wt of Vel. Frag (Gr) | Average Velocity (ft/sec) |
| 1 | Pressed Flake TNT | 26 | 34 | 60 | 43 | -- | Lost |
| 2 | Pressed Flake TNT | 39 | 64 | 103 | 38 | 11.8 | 3,830 |
| 3 | Pressed Flake TNT | 41 | 55 | 96 | 43 | -- | Lost |
| 4 | Cast Composition B | 65 | 83 | 148 | 44 | -- | Lost |
| 5 | Cast Composition B | 54 | 83 | 137 | 39 | 7.1 | 4,700 |
| 6 | Cast Composition B | 59 | 126 | 185 | 32 | -- | Lost |
| 7 | Cast 75/25 Cyclotol | 58 | 54 | 112 | 52 | 8.4 | 4,820 |
| 8 | Cast 75/25 Cyclotol | 84 | 130 | 214 | 39 | 5.2 | 5,310 |
| 9 | Cast 75/25 Cyclotol | 61 | 104 | 165 | 37 | 6.0 | 5,100 |
| Avg. | Pressed Flake TNT | 35 | 51 | 86 | 41 | 11.8 | 3,830 |
| Avg. | Cast Composition B | 59 | 97 | 156 | 38 | 7.1 | 4,700 |
| Avg. | Cast 75/25 Cyclotol | 68 | 96 | 164 | 41 | 6.5 | 5,080 |

*Panel Radius--30 feet

**Dist. to screen-14.8 ft.

TABLE 1 (Continued)

Fragment Weight Distribution*

| Round Number | Less Than 1 Grain Wt. (Gr) | Less Than 1 Grain Number | 1 - 25 Grains Wt. (Gr) | 1 - 25 Grains Number | 25 - 50 Grains Wt. (Gr) | 25 - 50 Grains Number | 50 - 75 Grains Wt. (Gr) | 50 - 75 Grains Number |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 5 | 247 | 41 | 292 | 8 | 0 | 0 |
| 2 | 2.5 | 5 | 496 | 74 | 184 | 5 | 51 | 1 |
| 3 | 0 | 0 | 473 | 63 | 160 | 4 | 0 | 0 |
| 4 | 8 | 14 | 461 | 74 | 149 | 4 | 0 | 0 |
| 5 | 0.5 | 1 | 588 | 108 | 0 | 0 | 0 | 0 |
| 6 | 6.5 | 16 | 513 | 87 | 255 | 8 | 66 | 1 |
| 7 | 3.5 | 5 | 519 | 97 | 68 | 2 | 0 | 0 |
| 8 | 0 | 0 | 447 | 92 | 0 | 0 | 0 | 0 |
| 9 | 15.5 | 33 | 520 | 110 | 164 | 5 | 192 | 3 |
| Avg. | 2 | 3.3 | 405 | 59.3 | 212 | 5.7 | 17 | 0.3 |
| Avg. | 5 | 10.3 | 521 | 89.7 | 135 | 4 | 22 | 0.3 |
| Avg. | 6 | 12.7 | 495 | 99.7 | 77 | 2.3 | 64 | 1 |

*Fragments recovered in 10 Celotex boxes in a semicircle of 14.8-ft. radius. No fragments recovered above 750 grains.

TABLE 1 (continued)

Fragment Weight Distribution*

| Round Number | 75 - 150 Grains Wt. (Gr) | Number | 150-750 Grains Wt. (Gr) | Number | Total Frags. Collected Above 1 Grain Wt. (Gr) | Number | Avg. Frag. Wt.-Above 1 Gr.-(Gr/Frag) |
|---|---|---|---|---|---|---|---|
| 1 | 96 | 1 | 221 | 1 | 856 | 51 | 16.8 |
| 2 | 0 | 0 | 0 | 0 | 731 | 80 | 9.1 |
| 3 | 80 | 1 | 154 | 1 | 867 | 69 | 12.6 |
| 4 | 116 | 1 | 0 | 0 | 726 | 79 | 9.2 |
| 5 | 0 | 0 | 0 | 0 | 588 | 108 | 5.4 |
| 6 | 307 | 3 | 0 | 0 | 1141 | 99 | 11.5 |
| 7 | 0 | 0 | 0 | 0 | 587 | 99 | 5.9 |
| 8 | 0 | 0 | 0 | 0 | 447 | 92 | 4.8 |
| 9 | 104 | 1 | 0 | 0 | 980 | 119 | 8.2 |
| Avg. | 59 | 0.7 | 125 | 0.7 | 818 | 67 | 12.8 |
| Avg. | 141 | 1.3 | 0 | 0 | 818 | 95 | 8.7 |
| Avg. | 35 | 0.3 | 0 | 0 | 671 | 103 | 6.3 |

*Fragments recovered in 10 Celotex Boxes in a semicircle of 14.8-ft radius. No fragments recovered above 750 grains.

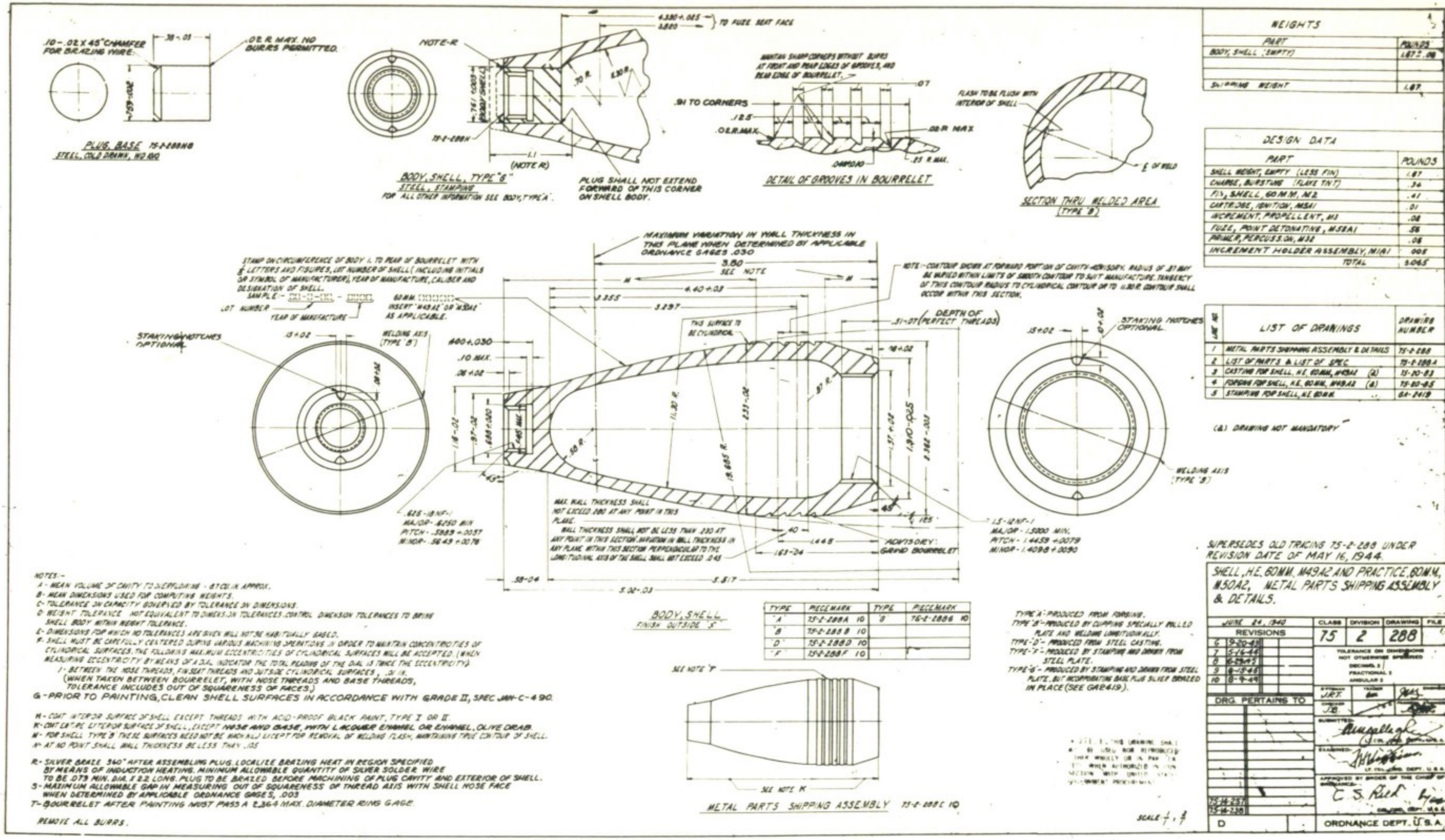
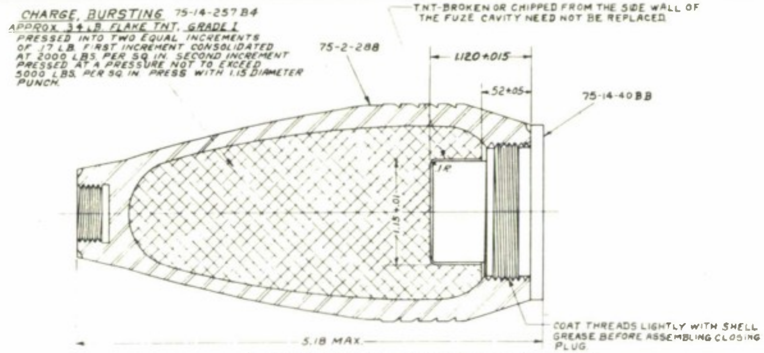


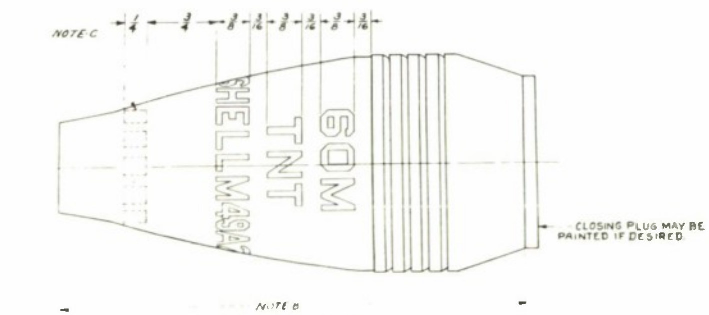

Fig 1 Metal Parts Shipping Assembly and Details of M49A2 60 mm HE Shell and M50A2 60 mm Practice Shell




SHELL LOADING ASSEMBLY 75-14-257A ◆

MEAN VOLUME OF CHARGE = 7.14 CU. IN.

| APPROX WEIGHTS | POUNDS |
|---|---|
| SHELL, EMPTY | 1.67±.06 |
| CHARGE, BURSTING (TNT) | .34 |
| TOTAL WEIGHT, UNFUZED | 2.01 |
| PLUG, CLOSING | .20 |
| SHIPPING WEIGHT | 2.21 |




MARKING DIAGRAM

NOTES –
A – MARK WITH YELLOW MARKING INK OR STENCIL PAINT
B – RETOUCH SURFACE WHERE PREVIOUS COATING IS DAMAGED WITH OLIVE DRAB LACQUER ENAMEL OR ENAMEL; BOURRELET MUST PASS A 2.364 DIAMETER RING GAGE
C – INSERT LOT NUMBER INCLUDING LOADER'S INITIALS OR SYMBOL

LIST OF PARTS

| LINE NO | NAME OF PART | NUMBER REQD PER COMPONENT | PIECE-MARK | SIZE OR FORM | MATERIAL KIND | GRADE | SPEC. NO. | APPROXIMATE UNIT WEIGHT (POUNDS) | APPROX. GROSS WT. OF RAW STOCK PER 1000 ASSEMBLIES | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SHELL LOADING ASSEMBLY | | 75-14-257A | | | | AXS-1466 | 2.21 | | |
| 2 | METAL PARTS ASSEMBLY | 1 | 75-2-288 | | | | | 1.67 | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | CHARGE, BURSTING | 1 | 75-14-257B | FLAKE | TRINITROTOLUENE | I | 50-13-5 | .34 | | |
| 6 | | | | | | | | | | |
| 7 | PLUG, CLOSING | 1 | 75-14-40BB | | | | 57-93-2 | .20 | | (b) |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | INK, MARKING, YELLOW | | 36-2 | | | (c) |
| 11 | | | | | LACQUER ENAMEL, OLIVE DRAB | I | 3-162 | | | (a) |
| 12 | | | | | GREASE, SHELL | | 50-11-37 | | | |
| 13 | | | | | | | | | | |
| 14 | | | | | | | | | | |

(a) - ALT - ENAMEL, LUSTRELESS, OLIVE DRAB, GRADE I, SPEC 3-67
(b) - REQUIRED ONLY IN LOADED SHELL WHEN FUZE IS NOT ASSEMBLED IN SHELL IMMEDIATELY AFTER LOADING.
(c) - ALTERNATIVE PAINT, STENCIL, YELLOW, SPEC 3-179

| LINE NO | LIST OF SPECIFICATIONS | SPEC. NUMBER ● | REQUIRED BY |
|---|---|---|---|
| 1 | AMMUNITION, EXCEPT SMALL ARMS AMM GENERAL SPEC FOR | 50-0-1 | DRG. 75-14-257 |
| 2 | | | |
| 3 | SHELL, HE, M49, FOR 60MM MORTAR ASSEMBLING, MARKING & PACKING | AXS-1466 | 75-14-257A |
| 4 | INK, MARKING | 36-2 | DRG 75-14-257 |
| 5 | PAINT, STENCIL | 3-179 | DRG 75-14-257 |
| 6 | GREASE, SHELL | 50-11-37 | DRG 75-14-257 |
| 7 | | | |
| 8 | PAINTS AND RELATED MATERIALS, GENERAL SPECIFICATIONS FOR | 3-1 | 3-67 |
| 9 | ENAMEL, LUSTRELESS | 3-67 | DRG 75-14-257 |
| 10 | STANDARD SPECIFICATIONS FOR MARKING SHIPMENTS | 100-2 | DRG 75-14-257 |
| 11 | TRINITROTOLUENE (TNT) | 50-13-5 | DRG 75-14-257 |
| 12 | LACQUER ENAMEL, LUSTRELESS | 3-162 | DRG 75-14-257 |

● THE SPECIFICATION NUMBERS SHOWN ARE BASIC NUMBERS ONLY. WHEN A SPECIFICATION IS REVISED, A LETTER IS AFFIXED TO ITS BASIC NUMBER. SPECIFICATIONS REFERRED TO IN THESE SPECIFICATIONS AND NOT LISTED HEREON SHALL NOT APPLY.

| LINE NO | LIST OF DRAWINGS | DRAWING NUMBER |
|---|---|---|
| 1 | SHELL LOADING ASSEMBLY | 75-14-257 |
| 2 | METAL PARTS ASSEMBLY | 75-2-288 |
| 3 | PLUG, CLOSING, FOR PROJECTILES | 75-14-40 |
| 4 | | |

SUPERSEDES OLD TRACING 75-14-257
UNDER REVISION DATE OF MAY 25, 1944

SHELL, HE, 60-MM, M49A2
LOADING ASSEMBLY AND MARKING DIAGRAM

JAN 21, 1941 | CLASS 75 | DIVISION 14 | DRAWING 257

REVISIONS: 1 4-7-41; 2 6-16-41; 3 5-25-44; 4 8-15-45

DRG. PERTAINS TO

RHW | EFL

C. S. Reed

ORDNANCE DEPT. U.S.A.

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Fig 2 Loading Assembly and Marking Diagram for M49A2 60 mm HE Shell

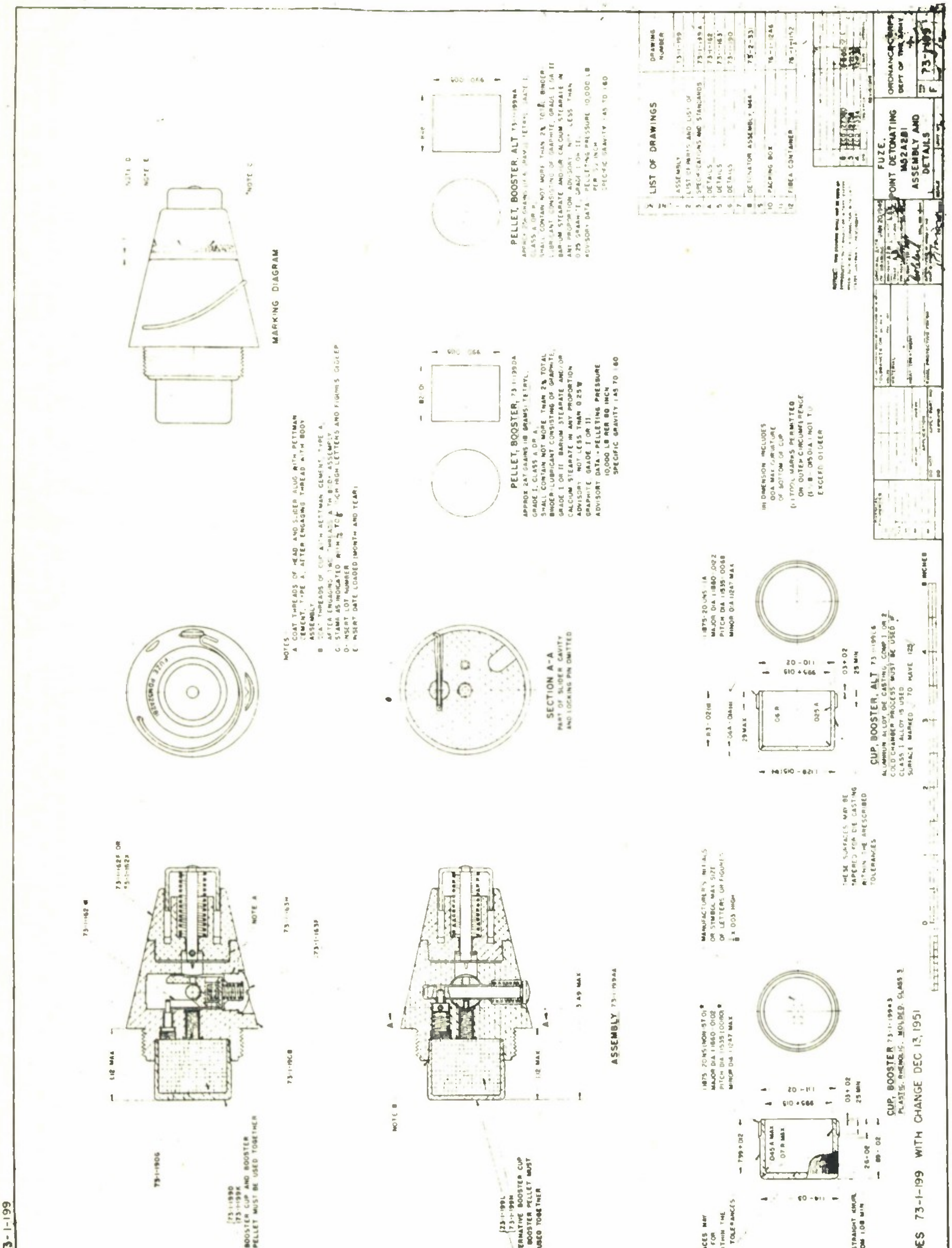

Fig 3 Assembly and Details of M52A2B1 Point Detonating Fuze

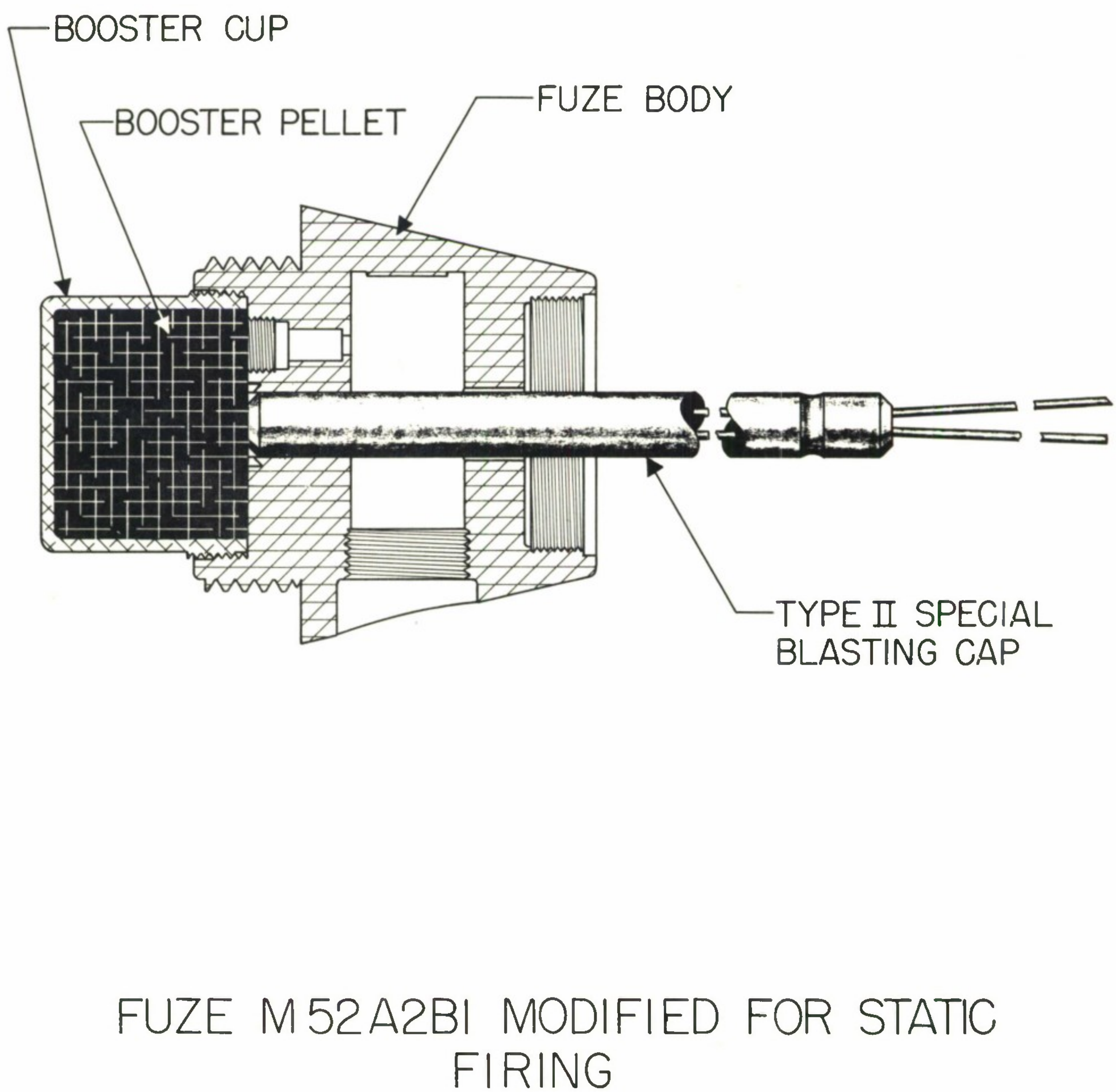


Fig 4 Fuze M52A2B1 Modified for Static Firing

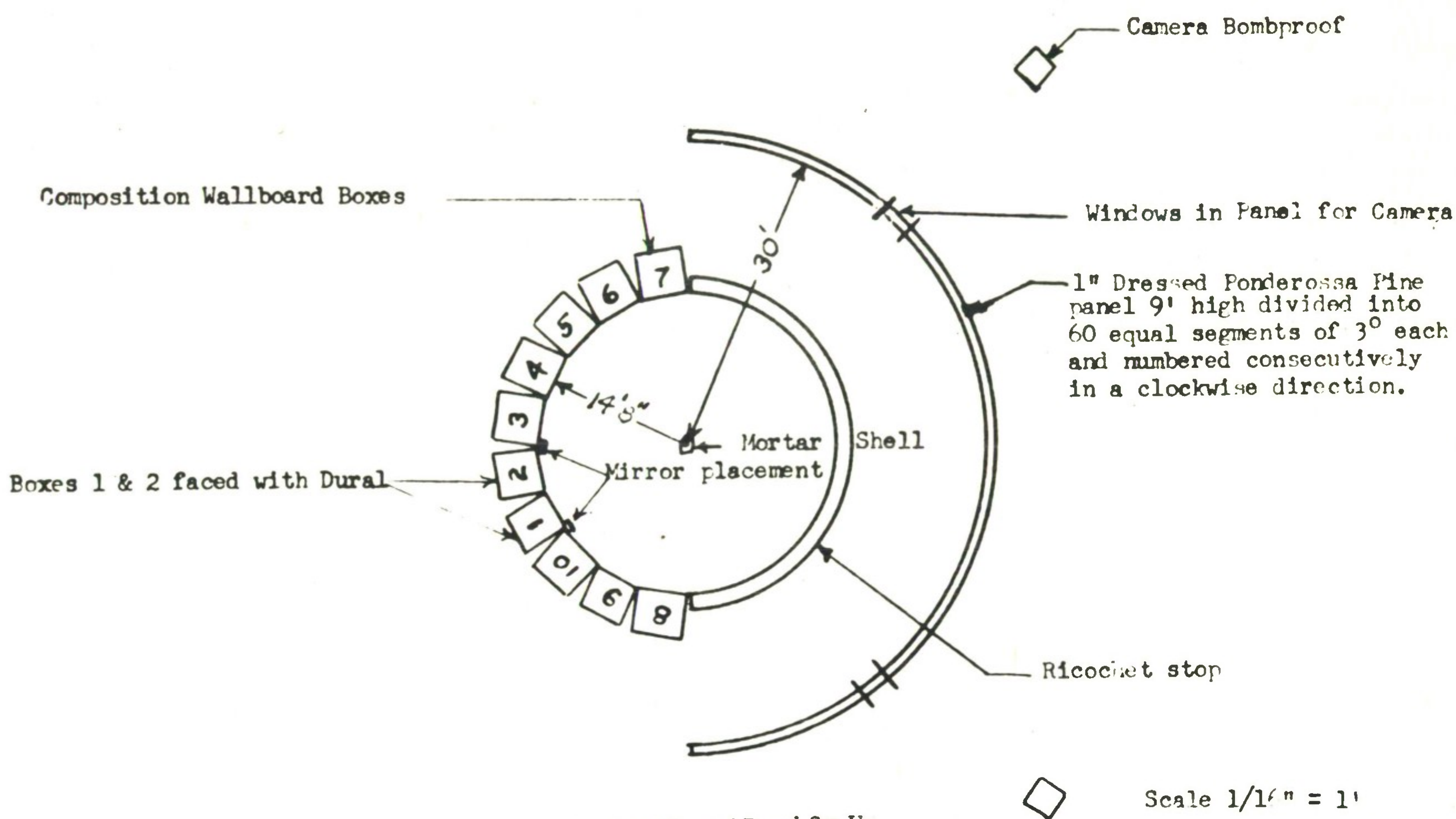


Fig 5 Plan View of Panel Set-Up

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